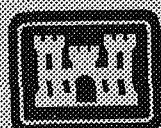

New Hampshire FPMS

Merrymeeting River Probable Maximum Flood At Alton Power Dam

February 1993



**US Army Corps
of Engineers**
New England Division

MERRYMEETING RIVER
PROBABLE MAXIMUM FLOOD
AT ALTON POWER DAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

FEBRUARY 1993

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MERRYMEETING RIVER PROBABLE MAXIMUM FLOOD
AT ALTON POWER DAM

1. INTRODUCTION

The New England Division of the U.S. Army Corps of Engineers has conducted a hydrologic analysis of the Merrymeeting River to determine the probable maximum flood (PMF) at the Alton Power Dam. The work was conducted at the request of the State of New Hampshire, under the Flood Plain Management Services (FPMS) program. The PMF is the flood resulting from the probable maximum precipitation (PMP). This precipitation was centered over the Merrymeeting River drainage area above Alton Power Dam. The PMP is "theoretically the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year" (Reference g).

The probable maximum storm for the Merrymeeting River was determined using the latest criteria on PMP estimates and applications as set forth in the Hydrometeorological Reports (HMRs) 51 and 52 (Reference f and g). Components of the probable maximum flood were routed through Merrymeeting Lake and the reservoir and storage area above Alton Power Dam to determine the results at the dam.

2. GENERAL DESCRIPTION

The Merrymeeting River Basin above Alton Power Dam, shown on Plate 1, lies southeast of Lake Winnepesaukee and covers a total area of approximately 36.1 square miles (sq. mi.). The Merrymeeting River discharges into Alton Bay, of Lake Winnepesaukee, approximately 1.6 miles downstream from the Alton dam. This area is somewhat well populated. Pertinent data on the dam can be found in Table 1.

The 11.4-square mile upper portion of the drainage area is rather mountainous and is controlled by the Merrymeeting Lake Dam. Merrymeeting Lake covers about 17 percent of its total drainage area. The net area (24.7 sq. mi.) between Merrymeeting Lake and the Alton dam is heavily forested, with a significant portion of the lower watershed being marshlands drained by Coffin Brook.

3. STUDY PROCEDURES

a. General. In this analysis the PMF was computed by developing storm rainfall for the Merrymeeting River watershed above the Alton dam (36.1 sq. mi.) and applying the precipitation to adopted unit hydrographs for each subbasin area (11.4 sq. mi. above Merrymeeting Lake Dam and 24.7 sq. mi. between the lake and Alton Power Dam). The Merrymeeting Lake inflow was routed through the reservoir to determine its outflow. This outflow was combined with the local inflow for the intervening drainage area between the dams (24.7 sq. mi.) to determine the total inflow hydrograph above the Alton dam. This inflow was routed through the total reservoir area above the dam to determine the maximum surcharge and peak outflow that would be expected from the probable maximum flood.

Table 1

ALTON POWER DAM
PERTINENT DATA

Structure

Top of dam elevation	529.3 ft. NGVD
Normal Pool elevation	526.1 ft. NGVD
Spillway Crest elevation (with stoplogs)	526.1 ft. NGVD
Spillway Crest elevation (without stoplogs)	523.3 ft. NGVD
Total length of Spillway	81.8 feet
Effective length of spillway	70.5 feet

Reservoir Surface Area

Spillway Crest (without stoplogs)	920 acres
Normal pool (s.c. with stoplogs)	1,170 acres
Top of Dam	1,410 acres

Surcharge Storage Capacity

At top of dam without stoplogs	7,070 acre-feet
At top of dam with stoplogs	4,130 acre-feet

b. Unit Hydrographs. There are no streamflow gages on the Merrymeeting River; therefore, to determine applicable unit hydrograph parameters, records from nearby gaged streams were reviewed. Mohawk Brook is a gaged, hydrologically similar, and nearby stream to the Merrymeeting River Basin. The Mohawk gage (drainage area = 8.9 sq. mi.) had a period of record of 13 years (May 1964 to July 1977) and is located just southeast of the Merrymeeting watershed. A unit hydrograph was developed for Mohawk Brook, using Snyder parameters previously developed during studies of similar areas in the Winnepesaukee River watershed. Using HEC-1 (Reference b), the Mohawk Brook Snyder unit hydrograph, and rainfall data associated with the storm of April 1973, a flood hydrograph was computed. This hydrograph approximately reproduced the 1973 storm's recorded hydrograph and, therefore, established confidence in the adopted Snyder parameters. Using HEC-1 and the adopted parameters, unit hydrographs were developed for both subbasin areas (Merrymeeting dam and net area above the Alton dam).

Pertinent data concerning the adopted 2-hour unit hydrographs are shown in Table 2, and the hydrographs are shown graphically on Plate 2.

c. Probable Maximum Precipitation. In this study, the "Probable Maximum Precipitation" (PMP) was developed using HMRs 51 and 52 (References f and g). Report 51 provides PMP area-depth-duration data by geographical location. Report 52 provides guidance in locating the PMP storm over a specified watershed. Computer program HMR 52 (Reference a) was used to facilitate the storm orientation and placement process. The outline of the drainage area above Alton Power Dam was digitized and coordinate points entered into the computer program along with an initial storm center, storm area-size, preferred orientation, and rainfall-area-duration data. The program varies the storm-area size and orientation in an attempt to optimize PMP depths over the drainage area; to produce the most critical probable maximum storm. The user is responsible for varying the storm centering to ensure calculation of the most critical PMP.

For the Merrymeeting watershed, the critical storm centering was at the centroid of the gross watershed; the critical storm-area size was 50 square miles; and the critical orientation was 223 degrees (see Plate 3). The resulting 72-hour PMPs for the two subbasins are shown in Tables 3A and 3B. Minimum loss rates were assumed at 0.05 inch per hour.

d. Probable Maximum Flood. The PMP was applied to the Merrymeeting Lake subbasin's adopted unit hydrograph to compute the PMF at Merrymeeting Lake. Outlet rating and storage capacity curves for the Merrymeeting dam were taken from the Phase I Inspection Report. These curves appeared reasonable and therefore, were adopted for this study. The computed PMF hydrograph was routed through surcharge storage, using the HEC-1 computer program (Reference b), and assuming the water surface initially at spillway crest (with flashboards) to produce an outflow hydrograph for Merrymeeting Lake. Local PMF for the net area above Alton Power Dam was computed using its PMP and adopted unit hydrograph. This inflow was combined with the outflow from Merrymeeting Lake, resulting in a total PMF hydrograph for the Alton dam with a peak discharge of approximately 30,100 cubic feet per second (cfs).

Table 2

ADOPTED UNIT HYDROGRAPHS
PERTINENT DATA

	<u>Merrymeeting Lake</u>	<u>Alton Power Dam Area</u>
Drainage Area (sq. mi.)	11.4	24.7
Tr (hours)	2	2
Qp (cfs)	670	1450
qp (cfs/sq. mi.)	59	59
Tp (hours)	3	3

Table 3A

UPSTREAM FROM MERRYMEETING LAKE DAM
PROBABLE MAXIMUM PRECIPITATION
 (From HMR 51)
 (Drainage Area = 11.4 square miles)

<u>Time</u> (hrs)	<u>Maximum</u> <u>Precipitation</u> (inches)	<u>Losses</u> (inches)	<u>Rainfall</u> <u>Excess</u> (inches)
0	0	0	0
2	0.12	0.1	0.02
4	0.12	0.1	0.02
6	0.12	0.1	0.02
8	0.14	0.1	0.04
10	0.14	0.1	0.04
12	0.14	0.1	0.04
14	0.18	0.1	0.08
16	0.18	0.1	0.08
18	0.18	0.1	0.08
20	0.25	0.1	0.15
22	0.25	0.1	0.15
24	0.25	0.1	0.15
26	0.35	0.1	0.25
28	0.39	0.1	0.29
30	0.43	0.1	0.33
32	0.77	0.1	0.67
34	0.95	0.1	0.85
36	1.26	0.1	1.16
38	3.95	0.1	3.85
40	13.63	0.1	13.53
42	2.43	0.1	2.33
44	0.65	0.1	0.55
46	0.55	0.1	0.45
48	0.48	0.1	0.38
50	0.30	0.1	0.20
52	0.30	0.1	0.20
54	0.30	0.1	0.20
56	0.21	0.1	0.11
58	0.21	0.1	0.11
60	0.21	0.1	0.11
62	0.16	0.1	0.06
64	0.16	0.1	0.06
66	0.16	0.1	0.06
68	0.13	0.1	0.03
70	0.13	0.1	0.03
<u>72</u>	<u>0.13</u>	<u>0.1</u>	<u>0.03</u>
TOTALS	30.31	3.6	26.71

Table 3B

MERRYMEETING LAKE TO ALTON POWER DAM
PROBABLE MAXIMUM PRECIPITATION
 (From HMR 51)
 (Drainage Area = 24.7 square miles)

<u>Time</u> (hrs)	<u>Maximum</u> <u>Precipitation</u> (inches)	<u>Losses</u> (inches)	<u>Rainfall</u> <u>Excess</u> (inches)
0	0	0	0
2	0.12	0.1	0.02
4	0.12	0.1	0.02
6	0.12	0.1	0.02
8	0.14	0.1	0.04
10	0.14	0.1	0.04
12	0.14	0.1	0.04
14	0.18	0.1	0.08
16	0.18	0.1	0.08
18	0.18	0.1	0.08
20	0.24	0.1	0.14
22	0.24	0.1	0.14
24	0.24	0.1	0.14
26	0.35	0.1	0.25
28	0.38	0.1	0.28
30	0.43	0.1	0.33
32	0.76	0.1	0.66
34	0.95	0.1	0.85
36	1.26	0.1	1.16
38	4.03	0.1	3.93
40	13.54	0.1	13.44
42	2.48	0.1	2.38
44	0.65	0.1	0.55
46	0.54	0.1	0.44
48	0.48	0.1	0.38
50	0.30	0.1	0.20
52	0.30	0.1	0.20
54	0.30	0.1	0.20
56	0.21	0.1	0.11
58	0.21	0.1	0.11
60	0.21	0.1	0.11
62	0.16	0.1	0.06
64	0.16	0.1	0.06
66	0.16	0.1	0.06
68	0.13	0.1	0.03
70	0.13	0.1	0.03
<u>72</u>	<u>0.13</u>	<u>0.1</u>	<u>0.03</u>
TOTALS	30.29	3.6	26.69

In developing an elevation-storage capacity relationship for Alton Power Dam, the relatively large wetland area along Coffin Brook and the Merrymeeting River was taken into consideration. Surface areas for elevations 520, 523, and 540 feet NGVD were estimated as shown on Plate 4. Surface areas for elevations 520 and 540 feet NGVD were determined by planimetering contours from the USGS quadrangle map. The delineated wetland boundary (also shown on the quad map) was estimated to be 523 feet NGVD, which corresponds to the permanent spillway crest of the Alton dam. The 523 feet NGVD area was also planimetered. These three values were used to plot the area versus elevation and develop the curve as shown on Plate 5. Surge storage volumes were determined using the conic method and points along the area-elevation curve. The surge storage capacity curve is also shown on Plate 5. Stage-discharge curves, with and without stoplogs in place, are shown on Plate 6 and were reviewed and adopted from the Alton Power Dam Phase I Inspection (Reference d).

Using HEC-1, the PMF hydrograph for Alton Power Dam was routed through the Merrymeeting River and estimated wetland storage, assuming normal pool levels at 526.1 feet NGVD with stoplogs in place. The dam outlet is only used as a reservoir drain; therefore, it was assumed closed. Table 4 provides the stage-discharge relationship for the Alton dam under pool conditions with and without stoplogs. This routing resulted in a peak stage of 536.9 feet NGVD (7.6 feet above top of dam). The peak outflow was approximately 18,900 cfs. The PMF development is shown on Plate 7, and resulting inflow and outflow hydrographs at Alton are shown graphically on Plate 8.

As a sensitivity analysis, initial conditions at the Merrymeeting dam were changed to a water surface level drained to elevation 645.5 feet NGVD (normal winter pool). Assuming 645.5 feet NGVD to be the initial reservoir level, and flashboards in place at elevation 648.5 feet NGVD, the PMF outflow was computed. During the same simulation, stoplogs at the Alton dam were assumed to be removed. This sensitivity analysis shows the best possible conditions for a PMF to occur (i.e., maximum available storage at both reservoirs) are when Merrymeeting Lake is at its generally lowest level and Alton Power Dam has its stoplogs removed. Results of this sensitivity test and routing the PMF during normal pool levels are shown in Table 5. Under these conditions, the Alton dam would be overtopped by 5.6 feet or about 2 feet lower than base PMF analysis.

4. SUMMARY AND CONCLUSIONS

Rainfall excess for the probable maximum storm, using HMR 51, was found to be 26.68 inches in 72 hours for the 36.1-square mile Alton Power Dam drainage area. Applying the current PMP excess to the developed Alton 2-hr. unit hydrograph, and adding the outflow from Merrymeeting Lake, resulted in a PMF inflow hydrograph with a peak flow of approximately 30,100 cfs. Routing this flood through the Merrymeeting River above the Alton dam, assuming normal pool conditions with stoplogs in place, resulted in a maximum height above top of dam of 7.6 feet and a peak outflow of about 18,900 cfs. In a sensitivity analysis of best possible conditions, storage

Table 4

MERRYMEETING RIVER
UPSTREAM OF ALTON POWER DAM
STAGE-DISCHARGE RELATIONSHIP

<u>Elevation</u> (ft, NGVD)	<u>DISCHARGES*</u>		<u>Surface</u> <u>Area</u> (acres)
	<u>Pool</u> <u>With Stoplogs</u> (cfs)	<u>Pool</u> <u>Without Stoplogs</u> (cfs)	
523.3 (spillway crest)	0	0	920
526.1**	0	1,100	1170
528.0	600	2,600	1320
529.3 (top of dam)	1,400	3,750	1410
531.0	3,600	6,400	1530
533.0	8,100	10,800	1680
536.3	—	20,000	1850
537.3	20,000	—	1900

NOTE: * Outlet used as a reservoir drain only, not included for discharges.

** Normal Pool Level due to stoplogs in place.

Table 5

MERRYMEETING RIVER AT ALTON POWER DAM
COMPARATIVE PROBABLE MAXIMUM FLOOD DATA
(Drainage Area = 36.1 square miles)

<u>Design Storm</u>	<u>Normal Pool Level</u> <u>(Using HMR 51)</u>	<u>Lower Pool Level</u> <u>(Sensitivity Study)</u>
Size (sq. mi.)	50	50
Design Rainfall (in)	30.28	30.28
Losses	3.6	3.6
Rainfall Excess	26.68	26.68
Duration (hrs)	72	72
<u>Unit Hydrograph</u>		
Unit Duration (hrs)	2	2
Peak Unit (cfs)	1,447	1,447
<u>Design Flood</u>		
Base Flow (cfs)	50	50
Peak Inflow (cfs)	30,100	28,600
Initial Pool (ft)	526.1	523.3
Peak Outflow (cfs)	18,900	16,200
Maximum Surge (feet NGVD) *	536.9	534.9
Height Above Dam**	7.6	5.6

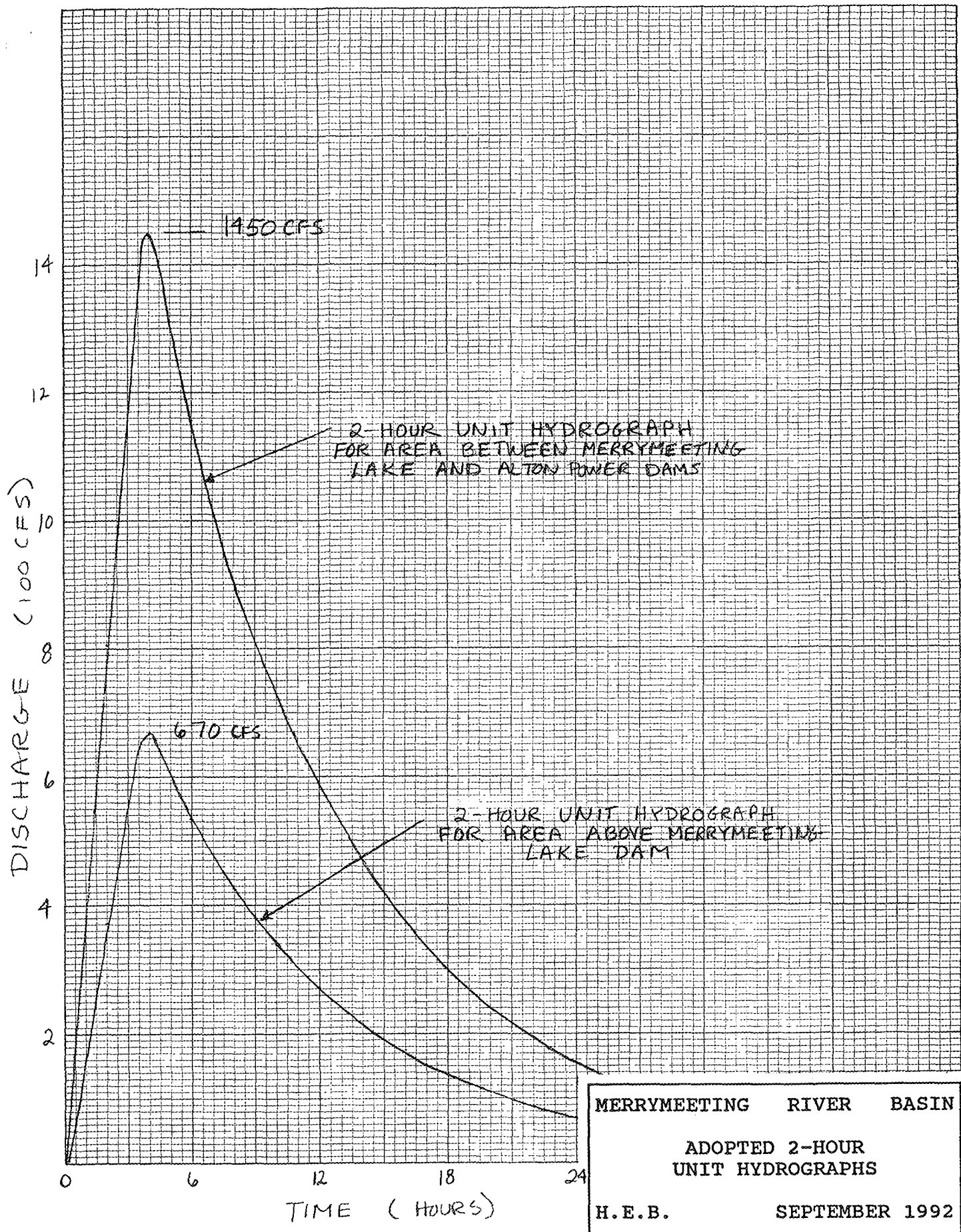
NOTES: * Permanent Spillway Crest = Elevation 523.3 feet NGVD
* Spillway Crest With Stoplogs = Elevation 526.1 feet NGVD
** Top of Dam = Elevation 529.3 feet NGVD

capacity between 645.5 and 648.5 feet NGVD (almost 6 inches of runoff at the Merrymeeting dam) was assumed available. Results of this analysis indicated only about 130 cfs contributed to the peak inflow at the Alton dam. Routing the inflow hydrograph resulted in a maximum height above top of dam of 5.6 feet, with a peak discharge of approximately 16,300 cfs.

It is concluded that the Alton Power Dam is not capable of discharging the probable maximum flood without overtopping the dam. However, it is recognized that the PMP is the "greatest depth of precipitation" theoretically possible.

5. REFERENCES

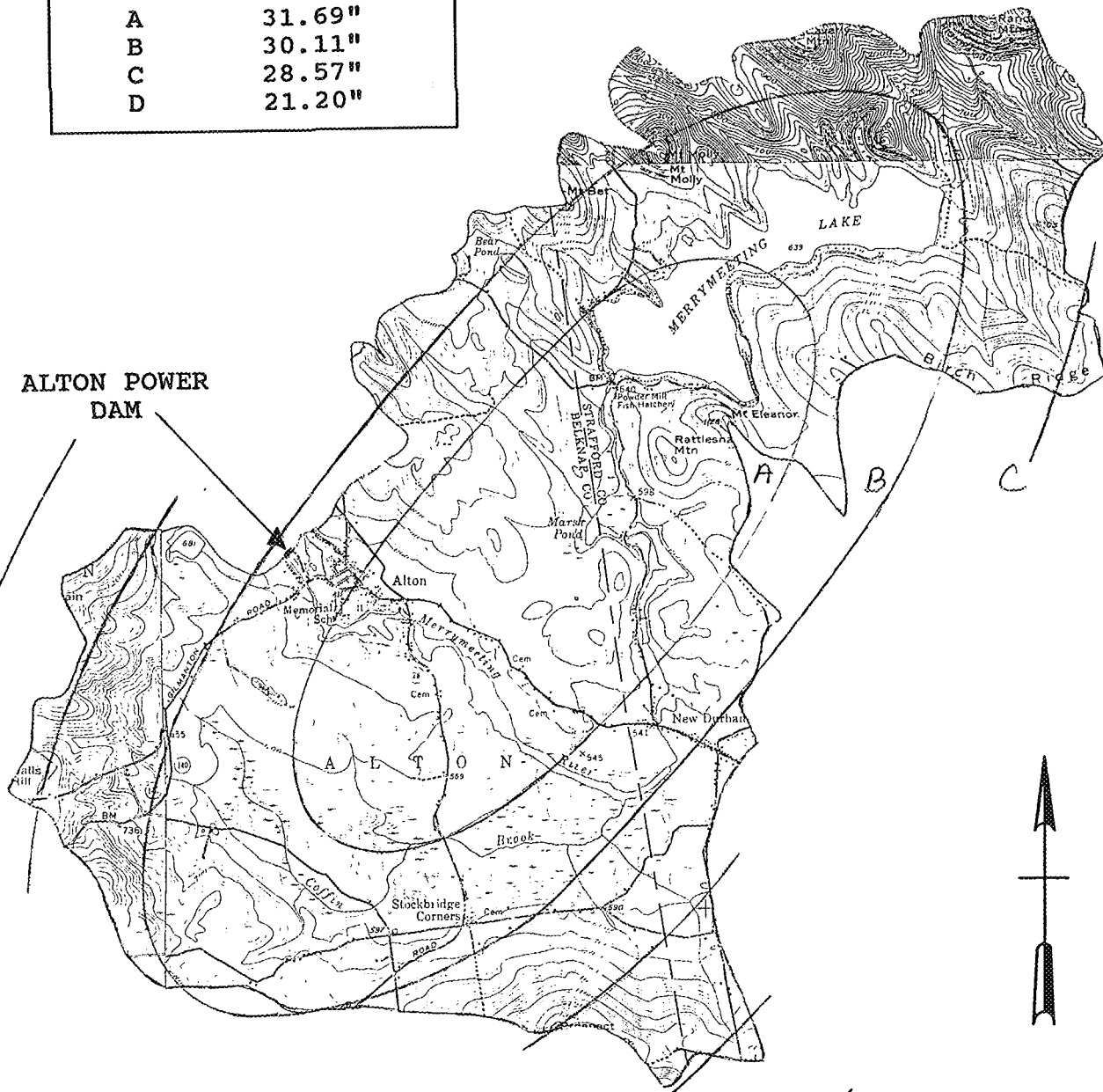
- a. U.S. Army Corps of Engineers, Computer Program HMR 52, "Probable Maximum Storm Computation," Users Manual, March 1984.
- b. U.S. Army Corps of Engineers, Computer Program HEC-1, "Flood Hydrograph Package," Users Manual, September 1990.
- c. U.S. Army Corps of Engineers, Engineer Manual 1110-2- 1405, "Flood Hydrograph Analyses and Computations," August 1959.
- d. U.S. Army Corps of Engineers, New England Division, "Phase I Inspection Report, National Dam Inspection Program, Alton Power Dam," January 1980.
- e. U.S. Army Corps of Engineers, New England Division, "Phase I Inspection Report, National Dam Inspection Program, Merrymeeting Lake Dam," October 1978.
- f. U.S. Department of Commerce, Hydrometeorological Report 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," June 1978.
- g. U.S. Department of Commerce, Hydrometeorological Report 52, "Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," April 1982.



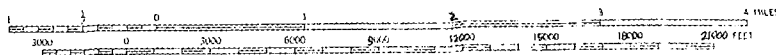
72-HOUR RAINFALL TOTALS

A	31.69"
B	30.11"
C	28.57"
D	21.20"

ALTON POWER
DAM



GRAPHIC SCALE

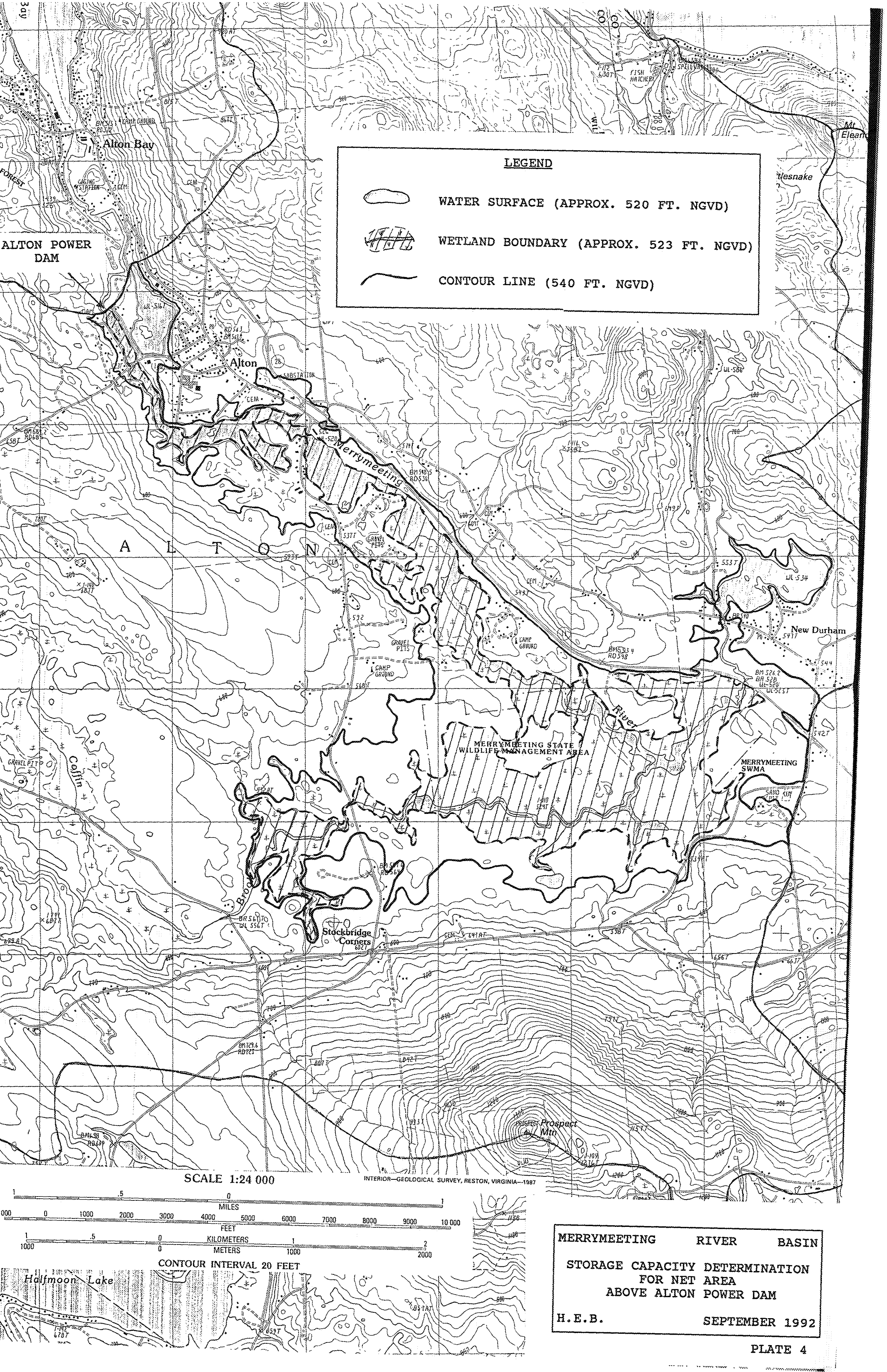


MERRYMEETING RIVER BASIN

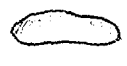
ALTON POWER DAM
PROBABLE MAXIMUM
PRECIPITATION

H E B.

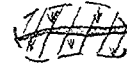
SEPTEMBER 1992



LEGEND



WATER SURFACE (APPROX. 520 FT. NGVD)



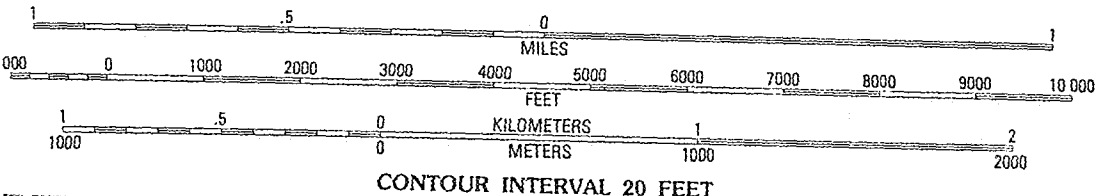
WETLAND BOUNDARY (APPROX. 523 FT. NGVD)



CONTOUR LINE (540 FT. NGVD)

SCALE 1:24 000

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1987

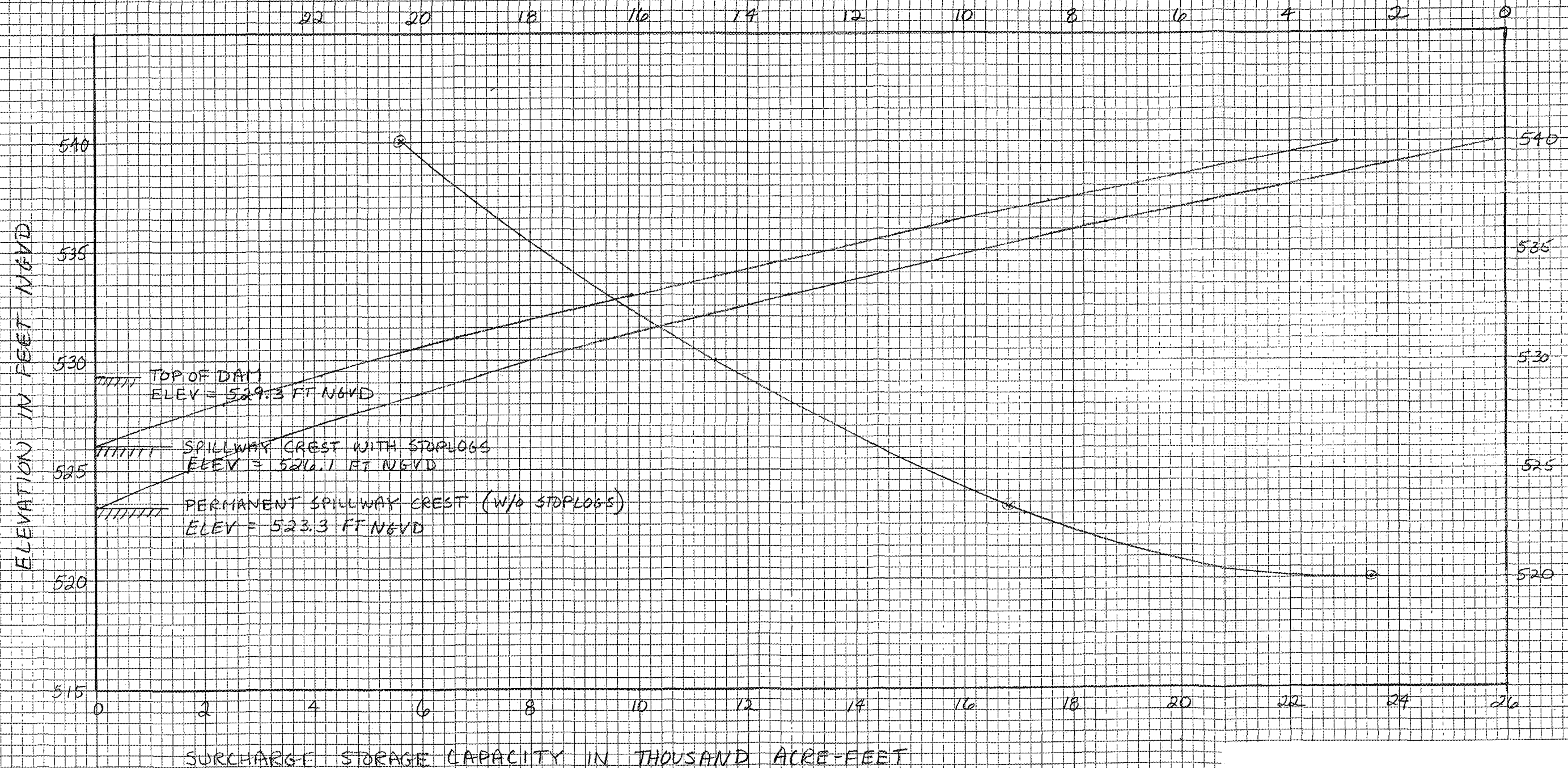


CONTOUR INTERVAL 20 FEET

MERRYMEETING RIVER BASIN
STORAGE CAPACITY DETERMINATION
FOR NET AREA
ABOVE ALTON POWER DAM
H.E.B. SEPTEMBER 1992

ALTON POWER DAM

AREA IN HUNDRED ACRES

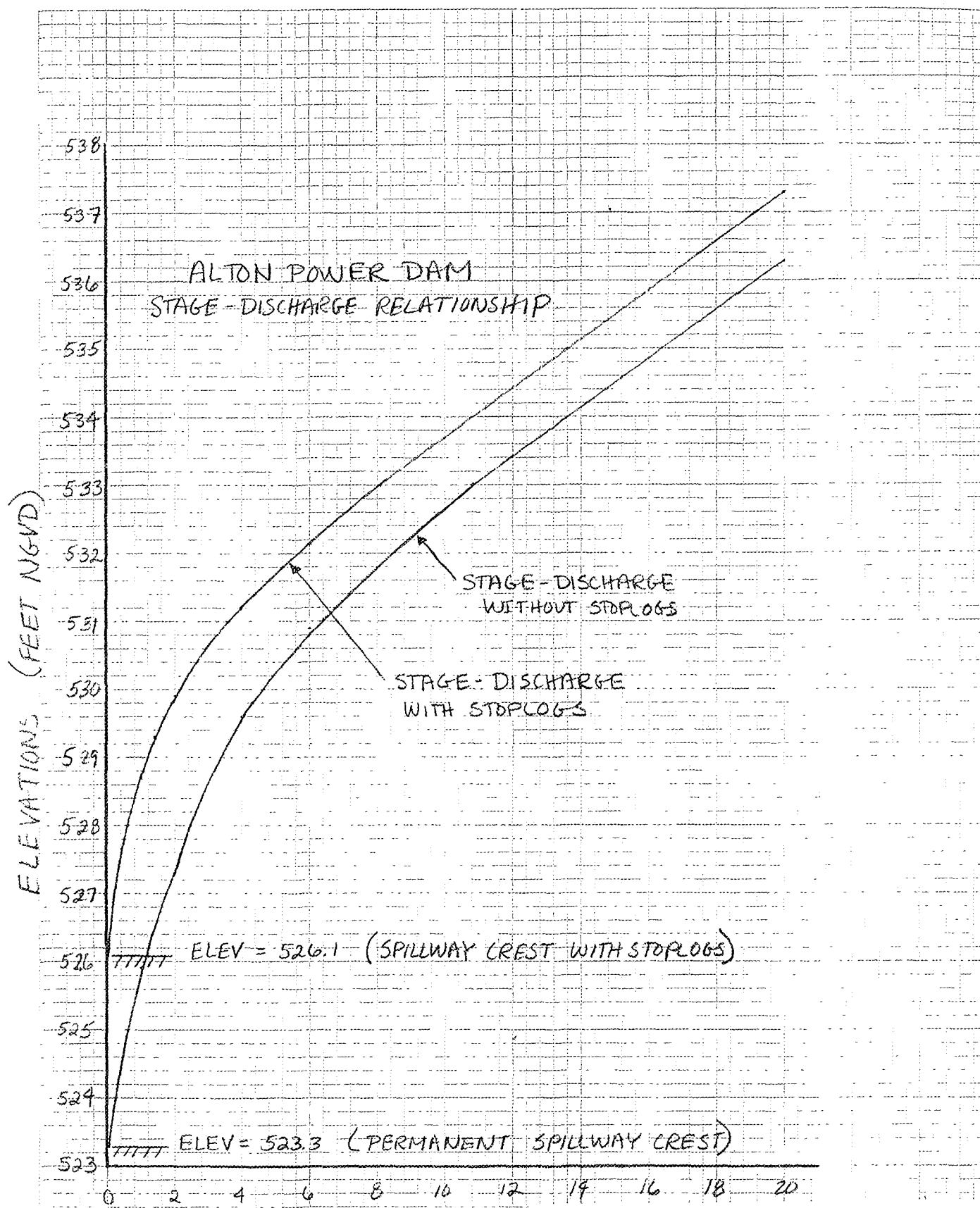


MERRYMEETING RIVER BASIN

ALTON POWER DAM
AREA AND CAPACITY CURVES

H.E.B.

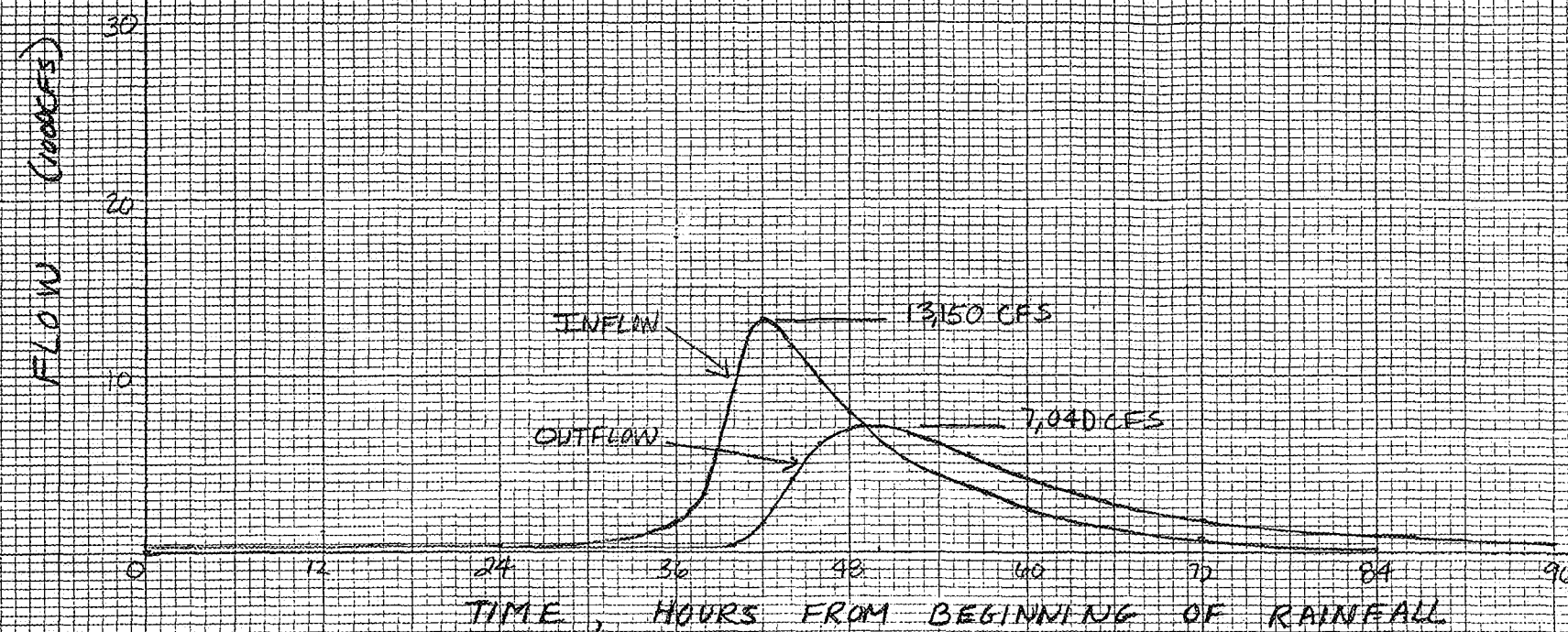
DECEMBER 1992



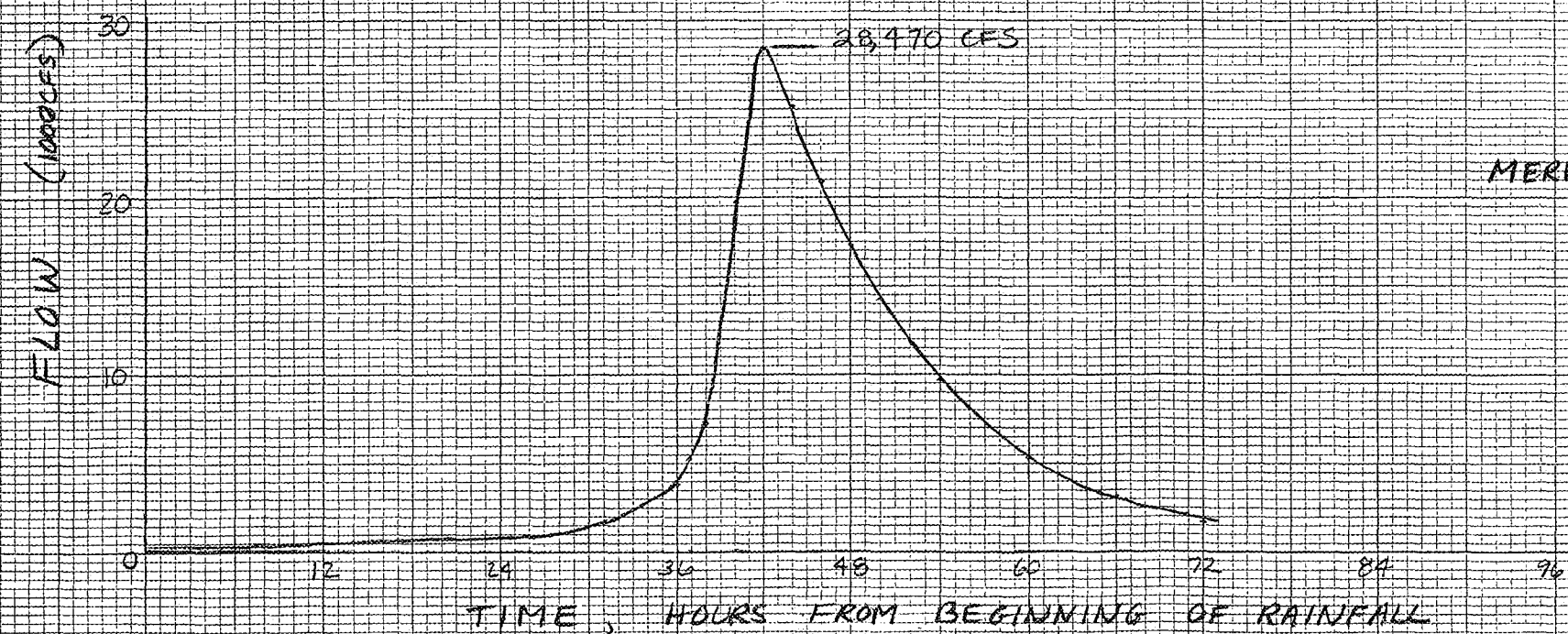
MERRYMEETING RIVER BASIN

ALTON POWER DAM
ELEVATION-DISCHARGE CURVES

H.E.B. DECEMBER 1992



MERRY MEETING LAKE
DISCHARGE
(D.A. = 11.4 SQ. MI.)



LOCAL RUNOFF
MERRY MEETING LAKE TO ALTON POWER DAM
(D.A. = 24.7 SQ. MI.)

MERRYMEETING RIVER BASIN

PROBABLE MAXIMUM FLOOD
INFLOWS TO
ALTON POWER DAM AREA

H.E.B. DECEMBER 1992

